RESULTS TO DATE OF STUDIES OF THE DURABILITY OF NATIVE WOODS TREATED AND UNTREATED

by

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With an introduction
by E. F. Rapraeger

Introduction

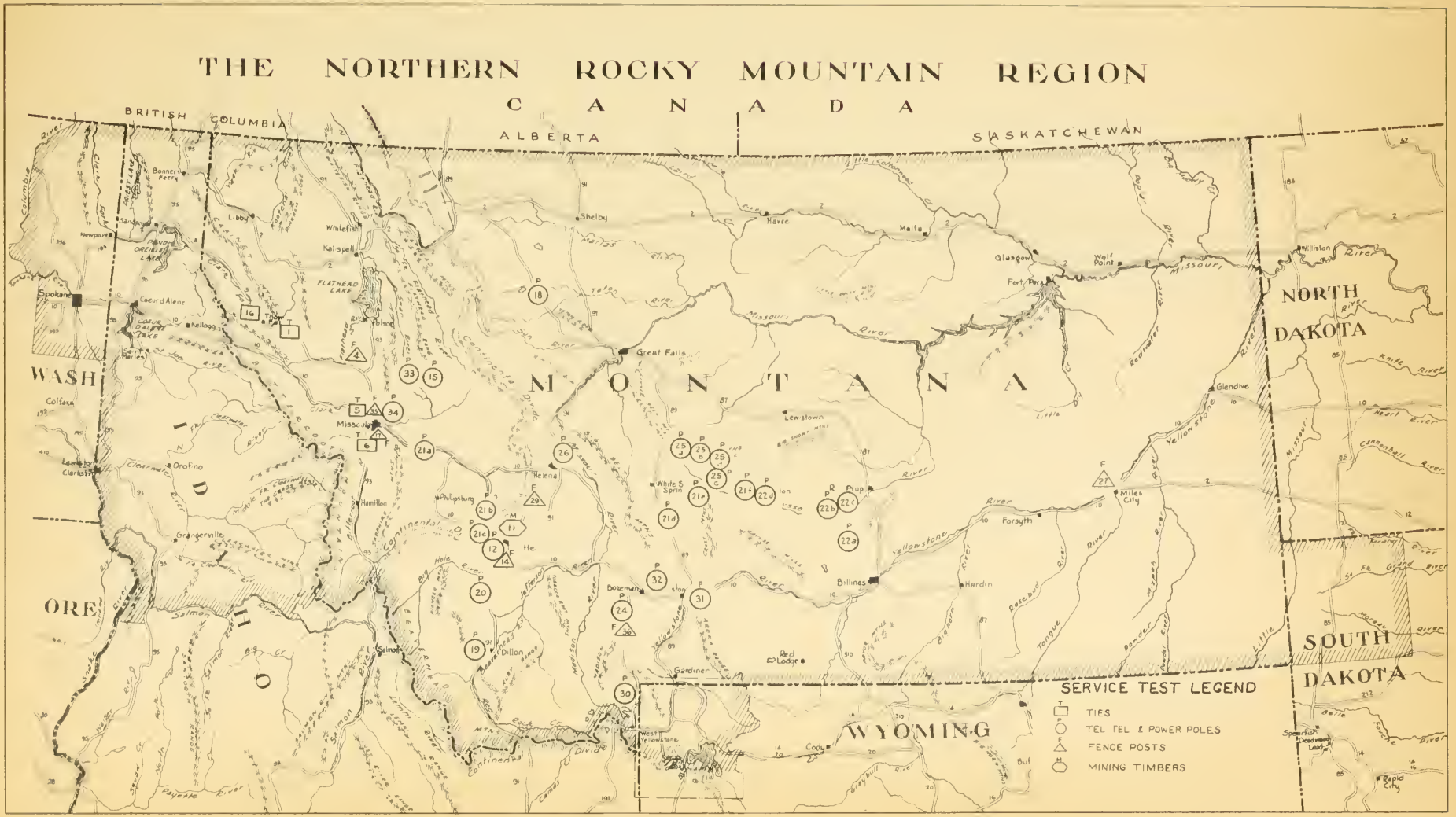
It pays to treat timber which is exposed to decay-favoring conditions. Not so many years ago, the average life of a fence post in service was from 5 to 10 years. Today the life expectancy of a similar post, properly treated, is over 20 years. Thirty-year posts are not uncommon. For example, two thirds of the treated posts in the fence which was built in 1909 at the National Bison Range, Moiese, Montana, are still in service after 32 years.

For a third of a century the Division of Forest Products at the Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Montana, has been observing the durability of native woods, treated and untreated. The division has service records for more than 31,000 telephone and power line poles, for over 1,000 stubs used in reinforcing poles, for over 11,000 fence posts, for more than 6,000 railway ties, and for 184 mining timbers. Some of this wood was set untreated to determine its natural durability and some was treated to permit of comparisons. Various preservatives were used; namely, zinc chloride; Anaconda Wood Preservative (arsenic trioxide), in dust, granular, and paste forms; sodium fluoride; tetrachlorphenol; lodgepole pine pitch; and the old stand-bys, coal tar-creosote or creosote-petroleum oil mixtures.

Keeping track of the different wood service tests and keeping the records current represent a lot of work. Mr. Whitney has been looking after these activities since 1918 - almost a quarter of a century. Prior to his tenure, the work was in charge of P. R. Hicks (1909-1915) and Harry N. Knowlton (1916-1917). Although Mr. Whitney deserves the bulk of the credit for carrying on the work in wood preservation, mention should also be made of George M. Hunt and R. M. Wirka of the Forest Products Laboratory and of former chieftains in the Division of Forest Products who rendered considerable assistance in various ways. These men are C. L. Billings (1920), S. V. Fullaway, Jr. (1921-1927), M. Bradner (1928-1934), and I. V. Anderson (1935-1939).

Writing this introduction gives me a lot of personal satisfaction. Like my predecessors, I have been enthused over the amount and the quality of the information which the products division has on the subject of wood preservation. To the best of my knowledge, the Division of Forest Products has more first-hand information on wood service tests than any other organization west of the Mississippi River. I have felt for a long time that this information should flow out to people who can profit from it. One obstacle after another presented itself, however. But now the job is done. Within a few hours I shall be resigning from the Forest Service to accept private employment. Before leaving, however, I have the satisfaction of writing the introduction to what I consider a very worthwhile report. The tree is bearing its fruit. I hope that the work in this worthwhile field of wood preservation fares as well in the future as it has in the past.

E. F. Rapraeger


THE NORTHERN ROCKY MOUNTAIN REGION
C A N A D A
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
M O N T A N A
WASH
IDAHO
ORE
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
Spokane
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Missoula
Great Falls
Helena
Butte
Bozeman
Billings
Miles City
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Havre
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Shelby
Kalispell
Whitefish
Hamilton
Dillon
Salmon
Lewistown
Phillipsburg
Granger ville
Gardiner
Cody
Red Lodge
Hardin
Forsyth
Glasgow
Wolf Point
Fort Peck
Williston
Rapid City
SERVICE TEST LEGEND
T TIES
P TEL TEL & POWER POLES
F FENCE POSTS
M MINING TIMBERS

Ahead of this page is a map with a service-test legend. Following it is a description of the different service tests. Below is an index.

Index

NATIONAL BISON RANGE FENCE - MOIESE, MONTANA

The National Bison Range, near Moiese on the Flathead Indian Reservation, was established in 1908. Originally it was a preserve for the vanishing bison, but since then other animals such as elk, deer, and mountain sheep have been placed in the preserve.

The area enclosed in the range is about 29 square miles and the length of the main outside boundary fence, about 24 miles. Construction of the fence, including treatment of the posts with creosote, was handled by the Forest Service. The fence was completed in the fall of 1909. Except for 380 untreated ponderosa pine posts and a few junipers, the fence posts were fire-killed western redcedar, 9 feet long and not less than 7 inches in diameter at the top. At least 95 percent of them were split posts.

All of the western redcedar posts were treated with creosote. The treatment consisted of an open-tank hot-bath treatment only, in which the butts of the posts were submerged in boiling creosote for 12 to 15 minutes. Although only a shallow penetration was obtained in the heart faces of the split posts, all checks and openings in the wood were completely filled with the preservative.

In observing the results from this quick, light treatment with creosote, several inspections of these posts have been made. More than 10,000 posts were originally set, but in the course of time some sections of the fence were reconstructed for administrative reasons, even though the posts were still in good condition. Therefore, when the latest inspection of the fence was made, in May 1941, it was necessary to record 1,284 of the original posts, removed for causes other than decay, as "eliminated." After eliminating that number, there were 8,682 of the cedar study posts still in the test. At the 1941 inspection, when the fence was 32 years old, approximately 34 percent of the test posts had been removed on account of decay, 2 percent contained decay in the treated butts, and 64 percent were in good condition.

All of the untreated ponderosa pine posts were removed in 1912 after they had been in service only $3\frac{1}{2}$ years.

Summarized records covering the examination made in 1941 are presented in table 1.

Table 1. - Condition of fence posts at the National Bison Range - Moiese, Montana.

Posts set in 1909.

Description of posts and preservative treatment	Average age at time inspected	Number in test	Condition of posts, May 1941				Estimated average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Western redcedar. Approximately 95 percent split, 5 percent round; 6- to 7-inch top diameter, 9 feet long; cut from sound, fire-killed timber. Butt-treated with coal tar-creosote in a hot bath for 12 to 15 minutes.	31.8	8,682	63.9	1.4	0.5	34.2	38.0
Ponderosa pine. Round, 6- to 7-inch top diameter, 9 feet long. Untreated.	-	380	-	-	-	100.0	3.5

Fence posts	Lodgepole pine	- Creosoted
	Lodgepole pine	- Untreated
	Western redcedar	- Untreated

AMMEN FENCE - MISSOULA, MONTANA

At the Western Montana Fair held in 1916 at Missoula, the Forest Service demonstrated the open-tank method of treating lodgepole pine fence posts with wood preservative by giving them a butt treatment with coal tar-creosote, using two 55-gallon drums as treating tanks.

When the fair ended the posts were set in a fence at the Ammen Place near the fairgrounds, and for the next 25 years close tab was kept on 36 of the posts in order to determine how long they would last. So far none have been removed on account of decay. The 36 butt-creosoted study posts were last examined in July 1941 after 24-3/4 years of service, at which time 25 were in good condition at the ground line, 9 were partly decayed but strong enough to give considerable additional service, 1 was so badly decayed as to require replacement within a year or two, and 1 had already been replaced on account of decay in the top. Only 2 posts showed much deterioration in the tops. It is a safe bet that these study posts will have an average life of 30 years or thereabouts. In contrast, a few untreated lodgepole posts set in another part of the same fence in 1916 had an average life of 10.2 years, which, by the way, is considered unusually high for such untreated posts. Some untreated western redcedar posts in the same fence had an average life of 16.4 years.

Additional records concerning the treated and untreated material included in this study are contained in table 2.

Table 2.- Condition of fence posts in the Ammen fence - Missoula, Montana.

Posts set in October 1916.

Description of posts and preservative treatment	Average age at time inspected	Number in test	Condition of posts, July 1941				Estimated average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. Round and split; 5-inch top diameter, 7 feet long. Butt-treated with coal tar-creosote by hot-and-cold bath process. Average absorption, 3.6 pounds per split post, 4.7 pounds per round post.	24-3/4	36 1/	69.4	25.0	2.8	2.8 2/	Approx. 30
Lodgepole pine. Round and split; 6- to 7-inch top diameter, 7 feet long. Untreated.	-	10	-	-	-	100.0	10.2
Western redcedar. Split; 5-inch top diameter, 7 feet long. Untreated.	-	51	-	-	-	100.0	16.4

1/ Originally there were 9 other treated lodgepoles in the test, or a total of 45. The 9 posts, although sound, were eliminated from the test because of disturbances.

2/ One post was removed on account of decay in the top. The treated butt of this post was sound when removed.

BABCOCK PLACER CLAIMS FENCE - ROCKER, MONTANA

Anaconda Copper Mining Company

In the spring of 1915, 610 lodgepole pine posts 7 feet long with 6- to 7-inch tops were pressure-treated with creosote in the treating cylinder of the Anaconda Copper Mining Company's wood-preserving plant at Rocker, Montana. No authentic records were kept of the treatment; hence the amount of creosote absorbed per post is unknown. The penetration was not great and probably varied from about 1/16 inch to 1/12 inch or more. All checks, however, were completely filled with creosote. These posts were made from fire-killed lodgepole, and since the posts were not fully peeled before treatment the absorption of creosote was not uniform.

All posts covered by this test were set in fence lines surrounding the Babcock placer claims of the Anaconda Copper Mining Company near Rocker, on which are located the clubhouse and target range of the Rocky Mountain Rifle Club.

The posts were last inspected on March 4, 1931, after 16 years of service. At that time approximately 62 percent of the posts were in good condition, 14 percent were decaying, and 24 percent had been removed on account of decay.

In 1931 the fence was badly in need of repairs and the owners were planning to rebuild it. When the fence was visited again it had been reconstructed. Some of the posts were reset upside down and some had been hauled away, making it impossible to maintain the continuity of the records. Therefore the study was abandoned.

Although it proved impracticable to keep track of these experimental posts until their average life could be accurately determined, an estimate based on the percentage of renewals, as shown by the Forest Products Laboratory's renewal chart, indicates that if there had been no disturbance of the posts they would have given an average life of about 21 years. This very low average for pressure-creosoted material tends to prove that the posts included in this installation did not receive a satisfactory treatment.

EXPERIMENTAL FENCES AT U. S. RANGE LIVESTOCK EXPERIMENT STATION - MILES CITY, MONTANA

These experiments are being conducted in cooperation with the Bureau of Animal Industry of the U. S. Range Livestock Experiment Station, Miles City, Montana, where 839 treated and 134 untreated fence posts of several different species were set in the fall of 1926. The purpose of these experiments was to determine the effectiveness of sodium fluoride and zinc chloride, applied by the steeping process, in prolonging the life of lodgepole pine, ponderosa pine, cottonwood, green ash, and western redcedar posts. Treatments with creosote-petroleum mixtures and with Anaconda Wood Preservative (dust) were also included in the tests.

The posts were peeled and seasoned for more than a year before treatment. Actual treating was done in the summer of 1926. In the fall the posts were set in various corrals at the livestock experiment station. Some untreated posts of each species were placed in the various fence lines for comparison with the treated posts. In the steeping treatments, the posts were given a full-length treatment by submerging them in cold-water solutions of zinc chloride and sodium fluoride for periods varying from 3 to 7 days. The average solution strength of the zinc chloride was 5.7 percent and that of the sodium fluoride, 2.95 percent.

The different groups of posts have been inspected at intervals of about 2 years. At the latest examination, made in May 1941 after about 14-2/3 years, most of the untreated posts had been removed. The round, untreated cottonwood posts gave an average life of 6.5 years; the untreated ash posts, 8.6 years; the untreated round lodgepole, 9.4 years; the untreated round ponderosa pine, 8.6 years; and the untreated split ponderosa pine posts. 8.3 years.

Comparative effectiveness of the various treatments has varied considerably for the different species, but in the groups treated by steeping the zinc-chloride treated posts are giving the best service. It is expected that the zinc-chloride treated cottonwood, lodgepole pine, and ponderosa pine posts will last at least twice as long as the untreated posts of these species.

Up till now, at least, the sodium fluoride and the arsenic treatments have proved to be about equal in effectiveness but not so good as zinc chloride. Results indicate that the posts treated with these preservatives will last from 2 to 7 years longer than untreated posts of the same species.

Detailed records resulting from the 1941 inspection of these study posts are contained in table 3.

Table 3.-Condition of fence posts at U. S. Range Livestock Experiment Station, Miles City, Montana.

Poets set in fall of 1926.

Speciee	Form	Average volume per post	Number in test	Preservative	Length of treatment	Average solution strength	Absorption of dry salt or oil: Pounds per cu. ft.	Absorption of dry salt or oil: Pounds per post	Condition of posts in May 1941 after 14-2/3 years of service: Good	Partly decayed	Badly decayed	Removed account of decay	Estimated average life
		Cu. ft.			Days	Percent			Percent	Percent	Percent	Percent	Yeare
Green ash	Round	.60	10	Zinc chloride	6-7	6.13	.46	.28	0.0	30.0	20.0	50.0	13.6
(F. Pennsylvanica,	"	.65	10	" "	3-4	6.10	.31	.20	0.0	10.0	30.0	60.0	12.5
var. lanceolata)	"	.75	19	Sodium fluoride	6-7	3.18	.28	.21	0.0	31.6	15.8	52.6	13.4
"	"	.68	12	Anaconda Wood Pres.(dust)	-	-	-	-	0.0	0.0	0.0	100.0	7.3
"	"	.62	12	Untreated	-	-	-	-	0.0	0.0	0.0	100.0	8.6
Native cottonwood	Round	1.37	6	Zinc chloride	6-7	6.07	.67	.92	0.0	0.0	16.7	83.3	13.1
"	"	1.25	19	" "	3-4	6.03	.48	.60	0.0	5.3	26.3	68.4	13.5
"	"	1.28	10	Sodium fluoride	6-7	3.09	.28	.36	0.0	0.0	10.0	90.0	9.5
"	"	1.42	13	" "	3-4	3.31	.17	.24	0.0	0.0	0.0	100.0	7.8
"	"	2.64	10	Creosote-petroleum mixt.	-	40-60 mixt.	11.8 (butte)		80.0	20.0	0.0	0.0	-
"	"	1.37	33	Anaconda Wood Pres.(dust)	-	-	-	-	0.0	3.0	3.0	94.0	9.3
"	"	1.28	7	Untreated	-	-	-	-	0.0	0.0	0.0	100.0	6.5
Lodgepole pine	Round	1.43	51	Zinc chloride	6-7	5.17	.35	.50	3.9	56.9	21.6	17.6	-
"	"	1.49	19	" "	3-4	5.47	.28	.42	5.3	31.5	5.3	57.9	15.5
"	"	1.74	36	Sodium fluoride	3-4	2.81	.095	.165	0.0	11.1	13.9	75.0	13.5
"	"	2.46	15	Creosote-petroleum mixt.	-	40-60 mixt.	4.0 (butte)		0.0	33.3	13.4	53.3	16.2
"	"	1.87	13	Anaconda Wood Pres.(duet)	-	-	-	-	0.0	53.8	23.1	23.1	-
"	"	1.62	20	Untreated	-	-	-	-	0.0	0.0	25.0	75.0	9.4
Ponderosa pine	Round	1.18	7	Zinc chloride	6-7	6.08	.75	.88	28.5	43.0	0.0	28.5	-
"	"	1.60	41	" "	3-4	5.74	.48	.76	34.2	21.9	7.3	36.6	-
"	"	1.30	33	Sodium fluoride	6-7	2.83	.25	.32	0.0	15.2	3.0	81.8	12.0
"	"	1.39	18	" "	3-4	3.03	.24	.33	0.0	11.1	0.0	88.9	10.4
"	"	1.42	26	Anaconda Wood Pres.(dust)	-	-	-	-	0.0	3.8	7.7	88.5	12.8
"	"	1.51	23	Untreated	-	-	-	-	0.0	0.0	0.0	100.0	8.6
Ponderoea pine	Split	1.44	18	Zinc chloride	6-7	5.34	.49	.70	27.8	55.6	5.5	11.1	-
"	"	1.68	20	Sodium fluoride	6-7	3.18	.27	.45	0.0	70.0	15.0	15.0	-
"	"	1.56	6	Anaconda Wood Pres.(dust)	-	-	-	-	16.6	50.0	16.7	16.7	-
"	"	1.74	6	Untreated	-	-	-	-	0.0	0.0	16.7	83.3	8.3
Western redcedar	Split	.79	24	Zinc chloride	6-7	6.20	.34	.27	62.5	25.0	4.2	8.3	-
"	"	.72	24	" "	3-4	6.18	.25	.18	58.4	33.3	8.3	0.0	-
"	"	.78	19	Sodium fluoride	6-7	3.21	.14	.11	42.1	52.6	5.3	0.0	-
"	"	.82	18	" "	3-4	2.32	.11	.09	33.3	66.7	0.0	0.0	-
"	"	5½" top	52	Anaconda Wood Pres.(dust)	-	-	-	-	42.3	51.9	5.8	0.0	-
"	"	5½" top	9	Creosote-petroleum mixt.	-	40-60 mixt.	2.4 (butte)		88.9	11.1	0.0	0.0	-
"	"	5½" top	42	Untreated	-	-	-	-	19.0	42.9	14.3	23.8	-
Summary of results for each preservative (irrespective of species and length of treatment) for both round and split posts			229	Zinc chloride	-	5.70			23.1	33.2	13.1	30.6	
			186	Sodium fluoride	-	2.95			7.5	28.5	7.5	56.5	
			34	Creosote-petroleum mixt.	-	-			47.1	23.5	5.9	23.5	
			142	Anaconda Wood Pres.(dust)	-	-			16.2	27.5	7.0	49.3	
All treated posts			591						17.9	29.8	9.5	42.8	
All untreated posts			110						7.3	16.4	10.9	65.4	
Grand total, treated and untreated			701						16.3	27.7	9.7	46.3	

1/ Originally there were 272 other posts in the test, or a totel of 973. The 272 were eliminated from the study when fences were torn down to make room for new barns, and for other reasons.

SQUAW CREEK RANGER STATION FENCE

Gallatin National Forest

Nearly all of the most important wood preservatives developed in recent years consist of a small percentage of one or more of the highly toxic chlorinated phenols such as tetrachlorphenol, pentachlorphenol, or orthophenylphenol, in a solvent or mixture of solvents other than water, usually light oils. In order to determine the chemical stability and general effectiveness of any new toxic material proposed for use as a wood preservative, the preliminary investigative work which it is possible to do in a laboratory must be supplemented by extensive field studies.

The Squaw Creek Ranger Station fence, in which 198 lodgepole pine posts treated by the open-tank process, using a preservative solution consisting of 3 percent tetrachlorphenol and 97 percent petroleum oil (by weight), were set in July 1935, now represents one of the earliest installations in which any of the toxic chemicals included in this group of new wood preservatives are being tested under actual service conditions in the field. These butt-treated posts were installed at the old Squaw Creek Ranger Station located in the Gallatin National Forest about 25 miles south of Bozeman, Montana, on the road to Yellowstone National Park.

The tetrachlorphenol for this experiment was contributed by the Forest Products Laboratory and was purchased from the Dow Chemical Company of Midland, Michigan. According to information from the Laboratory this chemical contained 95 percent toxic material. Approximately 90 percent was tetrachlorphenol and the rest of the soluble portion consisted of other chlorinated phenols such as trichlorphenol and possibly some pentachlorphenol. All of these chlorinated phenols are toxic to wood-destroying organisms.

The last inspection of these posts was made in May 1941. At that time, after about 6 years of service, 3 sound posts had been eliminated from the study because of disturbances, leaving 195 in the test. None of the 195 had been removed on account of decay, 1 post was partly decayed but still serviceable, and 194 were found to be in sound condition.

Fence posts	Lodgepole pine and Douglas-fir	-	Arsenic dust and untreated

SUNNYSIDE RANGER STATION FENCE

Deerlodge National Forest

In 1928, before the paste form of Anaconda Wood Preservative had been perfected or was being generally recommended for timber-treating purposes in western territory, 228 lodgepole pine and 55 Douglas-fir posts treated with 3 pounds per post of the Anaconda Copper Mining Company's treater dust were placed in a fence at the Sunnyside Ranger Station in the Deerlodge National Forest for a service test. Treatment of the posts was handled by employees of the Deerlodge Forest. As a check on the life of the treated posts, 22 lodgepole pine and 7 Douglas-fir posts were set untreated.

All of these experimental posts were green-cut, peeled, round posts ranging in size from 3 to 8 inches in top diameter. All were seasoned about 3 months before setting. They were set in gravelly and sandy soil in the summer of 1928.

Annual inspections of the posts were made by district rangers. A reliable indication of the results of the arsenic-dust treatment is afforded by an inspection which was made after 7 years of service. At that time nearly all of the treated lodgepole pine posts were decaying, with 21 percent of them reported to be badly decayed and 9 percent unserviceable or removed. Although the treated Douglas-fir posts examined were in better condition than the lodgepole posts, it is estimated that the average life of the treated fir posts would not have exceeded 10 years, and of the treated lodgepole would have proved to be about 8 years.

Similar inspections made of the untreated posts in the fence indicate an average life of 7 years for the Douglas-fir and an average life of 6 years for the lodgepole pine posts.

For the past several years Anaconda Wood Preservative in the form of treater dust has not been recommended by the Anaconda Copper Mining Company, and this study has been discontinued.

Inspection records and other data pertaining to this installation are presented in table 4.

Table 4. - Condition of posts in Sunnyside Ranger Station fence.
Deerlodge National Forest, near Basin, Montana.

Posts set in summer of 1928.

Description of posts and preservative treatment	Average age at time inspected	Number in test	Condition of posts			Estimated average life
			Good	Butt decaying	Unserviceable or removed	
	Years		Percent	Percent	Percent	Years
Lodgepole pine. Round, 5-inch top diameter. Treated with 3 pounds of Anaconda Wood Preservative (dust), applied 3/4 pound of dust at bottom, 3/4-pound ring of dust 12 inches from ground line, and 1½-pound ring 3 to 6 inches below ground line, when set.	7.1	228	8.8	82.4	8.8	8.0
Douglas-fir. Round, 5-inch top diameter. Same treatment as given to lodgepole pine.	7.1	55	60.0	40.0	-	10.0
Lodgepole pine. Round, 5-inch top diameter. Untreated.	6.1	22	9.1	27.3	63.6	6.0
Douglas-fir. Round, 5-inch top diameter. Untreated.	6.1	7	28.6	14.3	57.1	7.0

RAY RANCH FENCE - LAVALLE CREEK

The 50 cottonwood posts in this installation are of special interest because they were treated at very low cost with a solution consisting of one-third coal tar and two-thirds waste crankcase oil. It was desired to learn how effective a preservative solution of such low toxicity would be in increasing the life of fence posts in this region. These posts were butt-treated by the open-tank process, using a 5- to 6-hour hot and 4- to 12-hour cold bath treating cycle. They were treated and set by the ranch owner, Mr. J. H. Ray of Missoula, Montana, in May 1934 at his cattle ranch on Lavalle Creek about 8 miles northwest of Missoula.

Cost of the coal tar-crankcase oil solution amounted to approximately 6 cents per gallon. One gallon was sufficient to treat three posts, making the average cost for the preservative about 2 cents per post. Measurement of borings in the treated butts of these cottonwood posts showed approximately 1/4-inch radial penetration and 3- to 4-inch longitudinal penetration at the butt ends. After cooling, the treated butts were covered with a hard, shiny, black coating of the coal tar-crankcase oil mixture.

Although more than a thousand split cottonwood posts were treated by Mr. Ray and set in 1934, only 50 of these, constituting a representative sample, were selected for a service test. At an inspection made in September 1940 after these test posts had been in service 6-1/3 years, all were found to be in good condition showing no decay.

CHOTEAU - EAR MOUNTAIN TELEPHONE LINE

Lewis and Clark National Forest

This service test constitutes one of the earliest experiments with treated lodgepole pine material for use in pole lines. The study includes 449 butt-creosoted lodgepole pine stubs set in the fall of 1917 to reinforce small lodgepole pine and Douglas-fir poles in a telephone line originally constructed by the Forest Service in the Lewis and Clark Forest between Choteau, Montana, and the Ear Mountain Ranger Station. This pole line extends across open prairie country and is subject to severe stresses from winds. The experimental stubs set to support the old poles vary from 7 to 8 inches in top diameter and are 8½ feet in length. They were produced from green-cut lodgepole pine timber, seasoned for 6 months, and treated with creosote by the hot-and-cold bath process at the Anaconda Copper Mining Company's treating plant at Rocker, Montana.

The latest inspection of these pole stubs was made in May 1941, nearly 24 years after installation. At that time, 5 of the original stubs had been eliminated for causes other than decay (principally on account of damage from grass fires) and 444 were still included in the test. In 11½ miles of the line where every tenth stub was dug out for visual examination and sounding below the ground line, 96.4 percent of the stubs were found to be in good condition and 3.6 percent had been removed because of decay. These percentages are considered applicable to the entire test.

A more detailed statement covering the stubs examined during this inspection is presented in table 5.

Table 5. - Condition of stubs used in reinforcing the Choteau - Ear Mountain telephone line.
Lewis and Clark National Forest, Montana.

Pole stubs set in October 1917.

Description of stubs and preservative treatment	Average age at time inspected	Number in test	Condition of stubs, May 1941				Estimated average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. Average 7-inch top diameter, 8½ feet long, seasoned 6 months. Butt-treated with creosote by the hot-and-cold bath process. Average absorption, 9.8 pounds per cubic foot.	23.6	444 1/	96.4	-	-	3.6	Over 30

1/ Originally there were 5 more stubs in the test, or a total of 449. Four of these were badly damaged by grass fires and 1 was taken out on account of the construction of an irrigation ditch. All 5 were removed while still in sound condition.

LOWER GALLATIN DISTRICT TELEPHONE LINE
Gallatin National Forest

In the beginning this test included 280 butt-creosoted lodgepole pine stubs set in 1924 to reinforce old untreated Douglas-fir poles in a Forest Service telephone line constructed between Gallatin Gateway, Montana, and the Squaw Creek Ranger Station in the Gallatin National Forest.

On account of changes in the location of the line, some of the stubs have been eliminated from the test. At present, 243 of the original experimental stubs are still in the active test. These lodgepole pine stubs have an average top diameter of 7½ inches and are 8½ feet long. About 80 percent of them were cut from live timber and the rest were obtained from sound, fire-killed material. All were seasoned about 10 months before treatment. They were treated by the hot-and-cold bath process. The hot-bath temperatures ranged from 195° to 210° F. for from 3 to 6 hours, after which the fire was pulled and the creosote and stubs allowed to cool together over night.

The stubs cut from live timber absorbed an average of 1.2 gallons of creosote per stub, with an average penetration of about 1.3 inches. In the fire-killed lodgepole pine, an average absorption of creosote of about 3.8 gallons per stub with an average penetration of about 1.4 inches was obtained.

The latest inspection of these stubs was made in May 1941, after 17 years of service, by digging away the soil from the butt of each fifth stub. No indication of decay was found in any of the 49 stubs examined in this manner. The condition of the stubs inspected is believed to be representative of the entire line.

Table 6 contains the records obtained from this inspection.

Table 6. - Condition of stubs used in reinforcing Lower Gallatin District telephone line.
Gallatin National Forest, Montana.

Pole stubs set in spring of 1924.

Description of stubs and preservative treatment	Average age at time inspected	Number in test	Condition of stubs, May 1941				Average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. Average 7½-inch top diameter, 8½ feet long. About 80 percent cut from live timber and remainder from sound, fire-killed material. All seasoned 10 months and butt-treated with creosote by the hot-and-cold bath process. Average absorption of the live-cut stubs, 1.2 gallons and those from fire-killed timber, 3.8 gallons per stub.	17.0	243 1/	100.0	-	-	-	- 2/

1/ Originally there were 37 other stubs in the test, or a total of 280. These 37, although sound, were eliminated from the study when some changes were made in the pole line.

2/ Not in service long enough to permit of average life determination.

Pole stubs	Lodgepole pine	- Creosoted, arsenic granules and paste, and untreated

BOZEMAN - FLATHEAD TELEPHONE LINE

Bridger Canyon, Gallatin National Forest

This installation includes a very carefully planned series of tests undertaken to determine the relative effectiveness and value of Anaconda Wood Preservative in the granular and paste forms when compared with a hot-and-cold bath treatment, using a 40-60 creosote-petroleum mixture.

Originally it was planned to alternate pole stubs treated with Anaconda Wood Preservative (granules) and stubs treated with creosote-petroleum. After the treating work had been started, the Anaconda Copper Mining Company practically discontinued the sale of the granular form. The wood preservative paste put out by the same company was therefore used in treating part of the experimental stubs.

Altogether 299 lodgepole pine stubs, 7 to 11 inches in top diameter and 8 feet long, were set in 1929 and 1930. Three were untreated. The others were treated as follows: 142 stubs treated with about 7.4 pounds of Anaconda Wood Preservative (paste); 101 stubs treated with an average of about 1.5 gallons per stub of a 40-percent creosote, 60-percent gas-oil mixture by the hot-and-cold bath process; 53 stubs treated with about 6 pounds and 8 pounds of Anaconda Wood Preservative (granules).

The stubs were used to reinforce Douglas-fir poles 25 feet long in test sections covering 10 miles of a Forest Service telephone line extending from Bozeman, Montana, through Bridger Canyon to the Flathead Ranger Station in the Gallatin National Forest.

Seven inspections of the line have been made, the latest in May 1941 after about 11 years of service. At that time 56 percent of the paste-treated stubs examined were in good condition, 42 percent were decaying, and 2 percent had been removed on account of decay. All of the creosote-petroleum treated stubs, which on the average had been in service about one-half year longer than those treated with arsenic paste, were free from decay.

The showing made by the paste-treated stubs so far indicates that they may give an average life of about 14 years, or about twice as long as the untreated stubs of the same species in this test.

Additional records pertaining to these treated and untreated experimental stubs are contained in table 7.

Table 7.- Condition of stubs used in reinforcing Bozeman - Flathead telephone line. Gallatin National Forest, Montana.

Pole stubs set in 1929 and 1930.

Description of stubs and preservative treatment	Average age at time inspected	Number in test	Condition of stubs, May 1941				Average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. 7- to 11-in. top diam., 8 ft. long. Butt-treated with av. of 7.4 lbs. per stub of Anaconda Wood Pres. (paste) spread 1/8 in. thick over entire butt from ground line down.	10.7	122 1/	56.3	20.8	20.8	2.1	- 2/
Lodgepole pine. 7- to 11-in. top diam., 8 ft. long. Butt treated with 40% coal tar-creosote, 60% gas-oil solution by the hot-and-cold bath process. Average absorption, 1.5 gallons per stub.	11.3	85 3/	100.0	-	-	-	- 2/
Lodgepole pine. 7- to 11-in. top diam., 8 ft. long. Butt-treated with av. of 6 lbs. per stub of Anaconda Wood Pres. (granules) applied 1 lb. granules at bottom, 2-lb. ring granules 24 in. and 3-lb. ring 6 in. from ground line.	11.7	35	66.7	22.2	11.1	-	- 2/
Lodgepole pine. 7- to 11-in. top diam., 8 ft. long. Butt-treated with av. of 8 lbs. per stub of Anaconda Wood Pres. (granules) applied 1½ lbs. granules at bottom, 2¾-lb. ring granules 24 in. and 3¾-lb. ring 6 in. from ground line.	6.0	18	71.4	14.3	14.3	-	- 2/
Lodgepole pine. 7- to 11-in. top diam., 8 ft. long. Untreated.	-	3	-	-	-	100.0	7.1

1/ Originally 142 stubs were in the test; 20 have been eliminated because of road encroachments.
2/ Not in service long enough to permit of average life determinations.
3/ Originally 101 stubs were in the test; 16 have been eliminated because of road encroachments.

CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD COMPANY ELECTRIFICATION POLES - HARLOWTON, MONTANA, TO AVERY, IDAHO

In 1915 and 1916, when equipping its railway line for operation by electric power between Harlowton, Montana, and Avery, Idaho, the Chicago, Milwaukee, St. Paul, and Pacific Railroad Company installed 30,748 untreated western redcedar trolley and transmission poles. About 7 years later the railroad company and the Forest Service entered into a cooperative agreement to obtain service records and other data concerning these poles.

The trolley line from Harlowton to Avery is 440 miles long and the transmission line, 390 miles long. The route crosses two high divides, one in the Bitterroot Mountains and the other at Pipestone Pass on the main Continental Divide. Many different soil types are represented.

The bulk of the trolley poles averaged 13.2 inches in diameter at the ground line and were from 40 to 50 feet in length. Most of the transmission poles were from 45 to 55 feet long, with an average diameter of 14.9 inches at the ground line. About 90 percent of the trolley poles and 80 percent of the transmission poles were set in 1915. The rest were set in 1916.

In October 1922, after 7 years of service, it was found that with the exception of poles set in very wet locations decay had penetrated the sapwood in nearly all cases. This caused the railroad company to make plans for stubbing the poles whenever such reinforcement was needed. This policy, adopted in 1922, of reinforcing rotted poles with pressure-creosoted stubs has been rigidly adhered to. Consequently, very few poles have been replaced with new poles. Since practically all of the badly rotted poles were stubbed instead of being removed, the number of years of service up to the time of stubbing is used as a basis for average life determinations.

In September 1936, about 21 years after the poles were set, the entire stubbing program was completed. Data furnished by the railroad covering 29,718 poles stubbed from 1922 to 1936, inclusive, show that without stubs the trolley poles gave an average life of 17.3 years and the transmission poles, 17.8 years.

Summarized service records based on the company's reports are given in table 8.

Table 8. Condition of C. M. St. P. and P. Railroad Company electrification poles, Harlowton, Montana to Avery, Idaho.

Poles set in 1915 (80 percent) and 1916 (20 percent).

Description of poles	Type of poles	Number stubbed 1922 to 1936 1/	Average life before stubbing was needed
			Years
Western redcedar. Average diameter at ground line, 13.2 inches; 40 to 50 feet long. Untreated.	Trolley	23,262	17.3
Western redcedar. Average diameter at ground line, 14.9 inches; 45 to 55 feet long. Untreated.	Transmission	6,456	17.8
Total		29,718	17.4

1/ Although the entire line supposedly was stubbed in 1936 or prior thereto, fewer poles were stubbed (29,718) than were originally set (30,748), the difference amounting to about 3 percent. The disparity can be explained as follows: (1) Some of the original poles standing in marshy ground did not require stubbing. (2) Some poles were stubbed by the regular maintenance crews, and it may have happened that the poles were not included in the reports turned in by the special stubbing crew. (3) A few poles were damaged (snow slides, derailments, etc.) and instead of being stubbed were replaced by new poles.

MONTANA POWER COMPANY TRANSMISSION LINE CONNECTING HARLOWTON, LAVINA, ROUNDUP, AND BILLINGS, MONTANA

The 2,100 western redcedar poles included in this installation were cut in western Montana and Idaho. The standard pole size is 35 feet with 8-inch top, but about 10 percent of these poles were 40 feet long and a few were 50 feet and 55 feet. The poles were treated by immersing the butts for several hours in creosote heated to boiling temperature, after which they were allowed to remain in the cooling oil overnight.

Construction of the line was started on October 16, 1919, and completed about May 15, 1920. One branch parallels the Chicago, Milwaukee, St. Paul and Pacific Railroad main line from Harlowton eastward through Lavina to Roundup, and another branch extends in a southeasterly direction from Lavina to Billings. In October 1922, the Forest Service selected for periodical inspection 251 poles in four localities considered to be representative of soil and moisture conditions found in each of these branches. Since that time the power company has cooperated in keeping service records which when complete will permit of a determination of the average life of all the poles in the line.

In the period ending in 1939, 159 sound poles had been eliminated on account of changes in the routing of the line, leaving 1,941 of the original poles in test. Of this number, only 2 poles have been removed or stubbed because of decay. Both of these poles failed on account of heart rot below the ground line, which caused them to break off during high windstorms. In jacking up and resetting poles at various times when it became necessary to move a number of them, the company has reported the butts of such poles to be in excellent condition.

The latest service records collected by the Forest Service also show very little deterioration of the poles. In August 1939, after 19 years of service, 54 poles located in the test sections between Comanche and Broadview, near Lavina, and at Harlowton, were carefully inspected by digging away soil at the base of each pole. At that time, 52 of these test poles were found to be in very good condition and only 2 of them contained decay in the treated butts.

Detailed records of the test poles examined in 1939 are given in table 9.

Table 9.- Condition of poles in test section of Montana Power Company transmission line connecting Harlowton, Lavina, Roundup, and Billings, Montana.

Poles set in spring of 1920.

Description of poles and preservative treatment	Average age at time inspected	Number in test	Condition of poles, September 1939				Average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Western redcedar. 8-inch top diameter, 35 and 40 feet long. Butt-treated with coal tar-creosote by the hot-and-cold bath process. Average absorption, 4½ gallons per pole.	19.3	249	96.2	1.9	1.9	-	- 1/

1/ Not in service long enough to permit of average life determination.

DILLON - RATTLESNAKE CREEK TELEPHONE LINE
Beaverhead National Forest

When the Volstead Act became a law, the Forest Service purchased two malt tanks from the Beaverhead Brewery at Dillon, Montana, and used them for timber-treating purposes. In the summer of 1920, 209 seasoned lodgepole pine poles varying from 9 to 11 inches in diameter at the ground line, butt-treated with creosote by the hot-and-cold bath process in these tanks, were set in the Dillon-Rattlesnake Creek section of the Forest Service telephone line between Dillon and Jackson, Montana.

Within 17 years after setting, 108 of the original poles were eliminated from the test because of highway encroachments and the rerouting of a portion of the line. None of the poles reported as eliminated were removed because of deterioration from decay in the butts. Many of them were reset in another line several miles away.

An examination of this installation in May 1941, after approximately 21 years of service, showed that of the 101 original poles still in the test 13 had been removed on account of decayed butts, 1 was partly decayed at the ground line but still serviceable, and 87 were in good condition containing no noticeable decay in the butts.

Eight untreated lodgepole pine poles set in this line gave an average life of only 8.4 years, whereas 86 percent of the butt-creosoted poles have shown very little deterioration during 21 years of service.

Additional information pertaining to this study is given in table 10.

Table 10. - Condition of poles in Dillon - Rattlesnake Creek telephone line.
Beaverhead National Forest, Montana.

Poles set in summer of 1920.

Description of poles and preservative treatment	Average age at time inspected	Number in test	Condition of poles, May 1941				Average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. 9- to 11-inch diameter at ground line, seasoned. Butt-treated with creosote by the hot-and-cold bath process. Average absorption, 1.3 gallons per pole.	21.0	101 1/	86.1	1.0	-	12.9	Over 30 (Est.)
Lodgepole pine. 9- to 11-inch diameter at ground line. Untreated.	-	8	-	-	-	100.0	8.4

1/ Originally there were 108 other poles in the test, or a total of 209. The 108 were eliminated because of highway encroachments and other disturbances.

MISSOULA - SEELEY LAKE TELEPHONE LINE
Lolo National Forest

The main purpose of this experiment, which was started in 1915, was to collect information on the effectiveness of open-tank treatments which might aid in reducing the annual cost of maintaining pole lines in the national forests. Thus in April 1915, in line with this objective, 32 test poles were set in a Forest Service telephone line along the main road from Missoula, Montana, to Seeley Lake. The poles were located in a section of the line between Morrell Creek and the Seeley Lake Ranger Station.

These experimental poles were light, small lodgepole pine poles 18 feet long, averaging 5 inches in diameter at the top and ranging from 6 to 7 inches in butt diameter. They were butt-treated with creosote in various ways, some by a hot bath only, some by a cold bath only, and a few by the hot-and-cold bath process. All of the poles were set along the edge of irrigated land in gravelly and porous soils where conditions were very favorable to decay.

Although inspections of the poles were made in 1921, 1924, and 1926, this experiment was discontinued in 1926 when the telephone line was abandoned and all the test poles removed. At the final inspection in June 1926, after 11 years of service, 14 of the poles were in good condition, 4 were decaying, and 14 had been removed on account of butt decay.

The early decay of over 50 percent of these treated poles is attributable to the following causes:

1. The creosote was undoubtedly of a low grade, being amber in color and of about the same consistency as kerosene. It was also very volatile, evaporating rapidly at a temperature of 185° F.

2. The butts were not treated high enough to leave at least 6 inches of treated surface above the ground line when the poles were set.

3. The butts of some of the poles were not well barked before treatment and an uneven penetration resulted.

4. The hot-and-cold bath treatment, which is the best of the non-pressure methods, was used on only two of the poles, the rest being treated by either a hot bath or a cold bath alone.

Detailed records showing the condition of the poles at the final inspection in 1926 are given in table 11.

Table 11. - Condition of poles in Missoula - Seeley Lake telephone line.
Lolo National Forest, Montana.

Poles set in April 1915.

Description of poles and preservative treatment	Average age at time inspected	Number in test	Condition of poles, June 1926			Estimated average life
			Good	Butt decaying	Removed because of decay	
	Years		Percent	Percent	Percent	Years
Lodgepole pine. 6-inch top diameter, 18 feet long, cut from dry, fire-killed timber. Butt-treated with creosote, some by hot bath only, some by cold bath only, and a few by the hot-and-cold bath process. Average absorptions varied from 1/2 gallon to 1 gallon per pole.	11.2 1/	32	43.8	12.4	43.8	12

1/ Average age at final inspection. This experiment was discontinued in 1926 when the line in which these test poles were located was officially abandoned.

ROCKY MOUNTAIN RIFLE RANGE POLES - ROCKER, MONTANA

Anaconda Copper Mining Company

Although 52 lodgepole pine poles were treated for experimental purposes by the Anaconda Copper Mining Company in the fall of 1911, only 11 of these were included in this test.

The poles were butt-creosoted by an "empty cell" hot-and-cold bath process; that is, the ordinary hot-and-cold bath operations were followed with a hot bath for several hours for the purpose of recovering part of the oil. Penetration of the preservative averaged 1.38 inches, and the average absorption amounted to 4.3 pounds per cubic foot. The poles were set in April 1912. Four of them were used to support electric light wires adjacent to the company's wood-preserving plant at Rocker, Montana. The other seven served as markers and flag poles on a rifle range near Rocker.

At the inspections made at somewhat irregular intervals from 1915 to 1931, inclusive, each study pole examined was found to be in good condition. However, in 1919 one sound pole at the rifle range was removed to make room for an additional target frame, and in 1926 four sound poles in the yard adjacent to the treating plant were replaced with larger poles. In 1929 and 1930, three additional sound poles were removed at the rifle range and in consequence eliminated from the study.

When the three poles left in the study were last inspected in 1931, after approximately 19 years of service, they were entirely free from decay. Although the results from only three poles do not justify definite conclusions, they add weight to the results obtained from various other test lines which show that lodgepole pine poles given a hot-and-cold bath butt treatment with creosote, and used under the service conditions that prevail throughout much of the Rocky Mountain region, will effectively resist decay.

MT. HENRY TELEPHONE LINE
Lolo National Forest

In the spring of 1930, the ranger in charge of the Seeley Lake district of the Lolo National Forest started this experiment covering 48 green, peeled, western larch poles treated with an average of 5 pounds of Anaconda Wood Preservative paste when set. These were installed in a telephone line connecting the Mt. Henry Lookout Station and the district headquarters at Seeley Lake. About 60 percent of the poles were set in dry, gravelly soil and 40 percent in black loam or sandy loam soil. Each study pole was marked with a numbered identification tag.

Between the time of installation and the fall of 1940 no periodical inspections of these experimental poles were made. In September 1940 an inspection of the poles was made, but only 47 identification tags could be found. What became of the 48th is not known. All of the 47 poles found had been stubbed in June 1939. At this inspection it was learned that in the 9-year period from May 1930, when the poles were set, to the time of stubbing in June 1939 there had been no disturbance of the preservative. It was also learned that as a matter of administrative expediency some poles not actually in need of reinforcement in 1939 had been stubbed. Each of the 47 stubbed poles was therefore carefully examined below the ground line. The results of this examination showed that 6 poles had rotted off, 5 were badly decayed, 10 were partly decayed, and 26 were in good condition.

No additional data will be collected on this line because the treatment was disturbed in 1939. It is estimated, however, that if the 1939 stubbing project had included only the poles badly in need of reinforcement, the weighted average life obtainable in this test would have proved to be 13.5 years. Untreated western larch poles in this district do not usually have an average life of more than 7 years.

Detailed records resulting from the 1940 inspection of this installation are presented in table 12.

Table 12. - Condition of poles in Mt. Henry telephone line.
Lolo National Forest, Montana.

Poles set in May 1930.

Description of poles and preservative treatment	Average age at time inspected	Number in test	Condition of poles, September 1940				Estimated average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Western larch. 5- to 6-inch top diameter, 22 feet long; cut green, peeled, unseasoned. Treated with 5 pounds of Anaconda Wood Preservative (paste) when set.	10.3	47 1/	55.3	21.3	10.6	12.8	13.5

1/ Originally there were 48 poles set, but one was missing at the inspection made in September 1940 and therefore was eliminated from the test.

MISSOULA - MONTURE TELEPHONE LINE
Lolo National Forest

Although only 12 poles and 3 stubs are included in this study, the service records obtained from them to date add weight to evidence obtained from the paste-treated pole stubs in the Bozeman-Flathead telephone line (page 20), showing that a heavy treatment with Anaconda Wood Preservative paste will considerably prolong the life of such timbers. The test pieces were set during the spring of 1930 in the Rattlesnake Creek section of the Missoula-Monture telephone line, between Effinger Bridge and the Franklin Ranger Station in the Lolo National Forest.

These experimental poles and stubs were cut from green lodgepole pine timber and were partially seasoned when placed in service. A majority of the timbers were peeled clean of all bark to a point well above the ground line. They were treated with about 4 pounds of arsenic paste at the base and 6 pounds plastered against the pole or stub in the form of a collar extending from about 1 foot below the ground line to the surface. In this heavy treatment there is a thick coating of the paste extending from the ground line downward for 12 inches or more. The test timbers were not set continuously but were placed where needed as renewals or reinforcements throughout approximately 2 miles of line. These poles and stubs were set in gravelly clay soil.

The latest inspection of this installation was made in September 1940. At that time, after 10 years of service, 14 of the paste-treated poles and stubs were in good condition and 1 pole contained a pocket of decay within the treated zone.

Untreated lodgepole pine poles used in this line have required reinforcement or replacement within 6 years after setting.

Service records of the treated poles and stubs are contained in table 13.

Table 13. - Condition of poles and stubs in Missoula - Monture telephone line.
Lolo National Forest, Montana.

Poles and stubs set in spring of 1930.

Description of timbers and preservative treatment	Average age at time inspected	Number in test	Condition of poles and stubs, September 1940				Average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. 7- to 9-inch top diameter, cut green, seasoned for 6 months. Each pole and stub was treated with about 10 pounds of Anaconda Wood Preservative (paste) when set. Depth of setting averaged about 30 inches. From 3½ to 4 pounds of arsenic paste was placed at the base, and 6 to 7 pounds in the form of a collar was plastered against the pole or stub from about 12 inches below the ground line to the surface.	10.4	15	93.3	6.7	-	-	- 1/

1/ Not in service long enough to permit of average life determination.

HELENA - HILGER'S LANDING TELEPHONE LINE

Helena, Montana

In May 1926, the Gates-of-the-Mountains Transportation Company used 234 poles 20 feet long and 30 poles 25 feet long of green, peeled lodgepole pine in the construction of 11 miles of telephone line extending from a starting point on Montana Avenue, Helena, to Hilger's Landing on the Missouri River. The poles averaged 5 to 6 inches in top diameter.

Each pole was treated with 5 pounds of Anaconda Wood Preservative (dust) when set. About 1 pound of the preservative was placed in the bottom of the hole, and the rest was distributed between the bottom of the hole and a point about 8 inches below the ground line. The poles were set in gravelly to rocky soil of shale derivation.

From the very beginning inspections were made by representatives of the Helena National Forest. Their examinations were usually made by starting at a different pole each year, so that by inspecting each tenth pole throughout the line, each inspection report covered about 10 percent of the poles.

The final inspection of the poles was made on September 4, 1935, 9 years after the line was built. The results of that inspection are considered to be applicable to the entire line. At that time approximately 42 percent of the poles examined were in good condition and 58 percent were decaying. Assuming that all poles classed as being in good condition in the fall of 1935 would have an additional life of 5 years, those partly decayed 3 years, and those badly decayed 1 year, the poles in this line would give a weighted average life of 12.5 years. Untreated lodgepole pine poles in this locality do not have an average life expectancy of more than 7 years. At any rate, the results reported for this test indicate considerable benefit from the 5-pound treatment with Anaconda Wood Preservative (dust).

Summarized records covering the final inspection of these study poles are contained in table 14.

Table 14. - Condition of poles in Helena - Hilger's Landing telephone line.
Gates-of-the-Mountains Transportation Company.

Poles set in May 1926.

Description of poles and preservative treatment	Average age at time inspected	Number in test	Condition of poles, September 1935				Estimated average life
			Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
	Years		Percent	Percent	Percent	Percent	Years
Lodgepole pine. 5- and 6-inch top diameter, 20 and 25 feet long, unseasoned. Each pole was treated with 5 pounds of Anaconda Wood Preservative (dust), as follows: About 1 pound was placed at the bottom of the hole, and the rest distributed from the bottom to 8 inches below the ground line, as the hole was filled with earth.	9.3	224 1/	42.1	47.4	10.5	-	12.5

1/ Originally there were 40 other poles in the test, or a total of 264. The 40 poles were eliminated because of highway encroachments.

Poles	Lodgepole pine and Douglas-fir	-	Arsenic dust, granules, and paste
	Lodgepole pine	-	Untreated

MONTANA POWER COMPANY - TWO DOT TELEPHONE LINE
Lewis and Clark National Forest

The test included in this study covers 774 lodgepole and Douglas-fir poles treated with various forms of Anaconda Wood Preservative and 94 untreated lodgepole pine poles of comparable size. All of the poles were 25 feet long and averaged 6 inches in diameter at the top.

Lodgepole pine poles numbering 238, treated with 5 pounds of Anaconda treater dust per pole, were set in the fall of 1926. Fifty-one lodgepole pine poles set untreated in 1925 were shaved and treated with Anaconda paste in 1928. Douglas-fir and lodgepole pine poles numbering 485, treated with the granulated form of Anaconda Wood Preservative, 5 pounds per pole, were set in the summer of 1927. And 94 untreated lodgepole pine poles were set in the summer of 1927 in the Forest Service line from Spring Creek to Musselshell Ranger Station.

In 1930 and again in 1931, forest officers connected with the Lewis and Clark Forest cooperated with officials of the Montana Power Company in making two very detailed and complete inspections of the poles. At these two inspections the value of the treatments was somewhat impaired by disturbance of the preservatives. However, at both of the examinations the top soil which was moved to expose the butts of the poles to a depth of 6 inches was replaced as nearly as possible in its original form; and even at the 1930 inspection, when there had been no previous disturbance by digging, 24 percent of the poles treated with treater dust or with granules and 45 percent of the paste-treated poles were reported decaying after being in service only 3 to 5 years. The 1931 inspection showed a very rapid rate of decay in these poles. Seventy-two of those treated had been stubbed by then, and many more were reported to be badly decayed. From 1932 to 1934, inclusive, additional service-test data for this installation consisted of reports submitted by the Lewis and Clark Forest showing the number of treated and untreated poles stubbed each year. Reinforcement of all poles in each of the test groups was completed in 1934, approximately 7 years after the poles were treated.

In general, most of the poles in this test were set in dry soils unfavorable to the use of Anaconda Wood Preservative, especially in the treater-dust and granulated forms. Detailed inspection records and average-service-life data to time of reinforcement of the poles in each group by stubbing are presented in table 15.

Table 15. - Condition of poles in the Montana Power Company Two Dot telephone line and the Forest Service tap line from Spring Creek to Musselshell Ranger Station.

Poles set 1925-1928.

Description of poles and preservative treatment	Average age at time inspected	Number in test	Condition of poles			Average life without stubs
			Good	Butt decaying	Stubbed because of decay	
	Years		Percent	Percent	Percent	Years
Lodgepole pine. 6-inch top diameter, 25 feet long, seasoned. Butt-treated with 5 pounds of Anaconda Wood Preservative (dust) when set in August and September 1926. The dust was applied in three rings or layers, one near the bottom of the hole, another near the middle of the fill, and the other just under the ground line.	8	238	-	-	100.0	7.3 1/
Lodgepole pine. 6-inch top diameter, 25 feet long. Set green, untreated, in 1925. In 1928, after about 3 years of service, the butts of the poles were shaved and treated with Anaconda Wood Preservative (paste).	9	51	-	-	100.0	7.8 1/
Douglas-fir and lodgepole pine (mixed). 6-inch top diameter, 25 feet long, seasoned. Butt-treated with 5 pounds of Anaconda Wood Preservative (granules) when set in the summer of 1927. Treatment applied in the same manner as for the dust-treated group above.	7	485	-	-	100.0	6.1 1/
Lodgepole pine. 6-inch top diameter, 25 feet long. Set in summer of 1927. Untreated.	6	94 2/	-	-	100.0	6.0

1/ Represents average service life from time of setting to time of reinforcement by stubbing.
2/ Poles set in the Forest Service tap line from Spring Creek to Musselshell Ranger Station.

LIVINGSTON - MAIN BOULDER TELEPHONE LINE

Absaroka National Forest .

The material included in this experiment consisted of 14 Douglas-fir stubs and 78 lodgepole pine poles in a Forest Service telephone line extending from Livingston, Montana, to the Main Boulder Ranger Station in the Absaroka National Forest.

The Douglas-fir stubs were 7 inches in diameter at the top and 9 feet in length. They were peeled and set green in December 1927. In September 1928, each of these stubs was treated with Anaconda Wood Preservative (dust) by digging the soil away to a depth of 14 inches and applying 5 pounds of the dust in a complete ring around the stub and then filling in the soil and firmly packing it.

The lodgepole pine poles were 18 feet long and averaged 5 inches in top diameter. They were peeled and set green in June 1928. In August 1929, each one was treated with 5 pounds of Anaconda Wood Preservative (dust) in the same manner as described for the Douglas-fir stubs.

Use of Anaconda Wood Preservative for this maintenance work was solely on an experimental basis, and from 1929 to 1934 annual inspections were made of these stubs and poles. At the 1931 inspection, after less than 4 years of service, none of the poles and stubs were free from decay in the butts. In September 1934, after 7 years of service, all were reported to be unserviceable or removed on account of decay. Final computations show an average life of 6.6 years for the treated Douglas-fir stubs and 6.0 years for the treated lodgepole pine poles.

Practically all of these experimental poles and stubs were set in very gravelly and sandy, dry soils where the treatments with Anaconda Wood Preservative proved to be of little value.

Summarized service records for this study are given in table 16.

Table 16. Condition of poles and stubs in Livingston - Main Boulder telephone line. Absaroka National Forest, Montana.

Stubs and poles set in 1927 and 1928.

Description of timbers and preservative treatment	Number in test	Condition of poles and stubs, September 1934				Average life
		Good	Butt partly decayed	Butt badly decayed	Removed because of decay	
		Percent	Percent	Percent	Percent	Years
Douglas-fir stubs. 7-inch top diameter, 9 feet long, peeled and set green in December 1927. In September 1928, after being in service for 9 months untreated, each stub was treated with Anaconda Wood Preservative (dust) by digging the soil away to a depth of 14 inches and applying 5 pounds of dust in a complete ring around the stub, and then filling in the soil and firmly packing it.	14	-	-	-	100.0	6.6
Lodgepole pine poles. 5-inch top diameter, 18 feet long, peeled and set green in June 1928. In August 1929, after being in service for 14 months untreated, each pole was treated with 5 pounds of Anaconda Wood Preservative (dust), by the same method as the Douglas-fir stubs.	78	-	-	-	100.0	6.0

HEBGEN - WEST YELLOWSTONE TELEPHONE LINE

Gallatin National Forest

In the summer of 1927 a large number of untreated lodgepole pine telephone poles originally set in 1922 in a Forest Service line between Hebgen Dam and West Yellowstone, Montana, were so badly rotted that they were cut off and reset. While this maintenance project was under way, 76 of these poles were selected for a service test. Before the poles were reset they were treated with 2½ pounds of Anaconda Wood Preservative (arsenic dust) per pole. One pound of treater dust was placed in the bottom of the hole and 1½ pounds were placed 18 inches from the surface. The total cost of doing the job, including resetting in the same hole, amounted to 62½ cents per pole, of which 12½ cents was for preservative.

These reset experimental poles were inspected each year from 1930 to 1933, inclusive. In order to prevent disturbance of the preservative, the ground-line method of inspection was used. At the examination made in August 1930, after 3 years of service, 4 of the 76 poles had rotted off and the rest showed decay from 1/4 to 1 inch deep. In 1931, 3 additional poles had rotted off. In 1932, a total of 22 of the 76 treated poles were reported rotted off, with the rest showing rot from 1/2 to 2 inches deep. At the final inspection, which was made on August 16, 1933, all of the treated poles had either been reset a second time or been replaced. Computations show that the average length of service from the time these poles were treated until they were replaced was 5.6 years.

In a study by the questionnaire method several years ago, the Forest Products Laboratory requested several telephone companies to report on the results that they were getting with reset poles. Estimates from different sources varied considerably, but the average indicated that about half the original life might be expected if they should be reset without preservative treatment. On that basis, assuming that untreated lodgepole pine poles in this line may have an average life of 7 years, the added life without treatment would be 3.5 years. Using this figure for comparison, the arsenic treatment given to reset poles in the Hebgen-West Yellowstone line increased their life by approximately 2 years.

SPRING RANGER STATION - MELROSE TELEPHONE LINE
Beaverhead National Forest

This experiment was begun by the Forest Service in 1913 to determine the suitability of pitch-treated lodgepole pine trees for poles. A total of 152 lodgepole pine trees suitable for small poles, growing on the Beaverhead National Forest near Melrose, Montana, were selected for the experiment. The bark, with the exception of a vertical strip about 2 inches wide to sustain growth, was removed from each tree to a height of about 5 feet above the ground. 1/ A high resin content was thus produced in the butts of the living trees since the barking caused a heavy flow of resin in the peeled areas. The trees were cut into poles 8 years later, at which time they were heavily impregnated with pitch in the peeled areas to a depth of about 1½ inches. The growth of the trees during the 8-year period before cutting caused the formation of a ridge of wood under the 2-inch strip of bark, and an examination of this ridge on each pole indicated a low pitch content, probably about the same as in the wood above the peeled area.

Seventy-one of the poles were used in June 1921 for a Forest Service telephone line between the Spring Ranger Station and the town of Melrose, Montana. Most of the poles were 22 feet in length, averaging 7 inches in diameter at the top. All bark, including the vertical 2-inch strip at the butt, was peeled off and the poles were set so that at least 3 inches of the pitched area was above the ground.

In September 1928, after 7¼ years of service, 51 percent of the total number originally set had already been removed or were so badly decayed in the butts as to warrant removal. It is estimated that these poles gave an average life of about 8 years, which would be only about 1 year longer than the average service life of untreated lodgepole pine poles in the same locality. Consequently, there seems to be little to recommend in the pitch treatment as it was used in this experiment. Examination of these poles has shown that the principal weakness of this method of increasing the life of poles is the ridge of untreated wood that grows under the strip of bark left to sustain growth in the tree. All of the poles were attacked by fungi in this untreated ridge.

1/ A patent (No. 655,638) covering this method of treating trees to be used for fence posts was issued to I. G. Robinson of Brooklyn, Alabama, on August 7, 1900.

NORTHERN PACIFIC RAILWAY - PLAINS TEST TRACK
Plains, Montana

Thirty-five years ago the Forest Service entered into a cooperative study of cross ties with the Northern Pacific Railroad. The investigation consisted in three separate experiments: First, tests to determine the green weight and rate of seasoning of timbers cut in different months; second, tests to determine the absorptive power of seasoned timbers cut in different months; third, tests to determine the comparative durability of green, of seasoned, and of treated timbers when laid under similar conditions with various tie plates and rail fastenings in a test track. The third experiment, dealing with durability, is the only one which will be described in this paper.

In order to carry on the durability study, the railroad established a test track in its main line near Plains, Montana, early in 1907. The test included 2,260 untreated western larch and Douglas-fir ties plus 390 zinc-chloride treated ties of the same species. Treatment of the ties was done under pressure, using a 6-percent solution of zinc chloride. Absorption of the preservative amounted to approximately 0.8 pound per cubic foot. All of the treated ties and most of the untreated were set in a filled roadbed which is well drained.

Results of this experiment, given in table 17, show that the average life for the untreated larch was 7.35 years and for the untreated Douglas-fir, 7.65 years.

The treated Douglas-fir ties gave an average life of 17.5 years and the treated western larch, an average life of 18.6 years. The service life obtained from these zinc-chloride treated ties is considered to be above the average generally obtainable from this type of preservative. After some years of service all of the ties in this test were turned over, which procedure undoubtedly increased their life. Use of a 6-percent solution resulting in a net retention of 0.8 pound of dry salt per cubic foot, rather than the 4-percent solution with 1/2-pound net retention specified in many instances for zinc-chloride treatments, also tended to prolong the life of these test ties.

Table 17. - Summary of results for the Northern Pacific test track near Plains, Montana.

Ties set in spring of 1907.

Description of ties and preservative treatment	Date of final inspection	Number in test	Total renewals because of wear, breakage, splitting, and decay	Average life
			Percent	Years
Douglas-fir. Pressure-treated with zinc chloride, 0.8 pound per cubic foot.	June 1932	197	100.0	17.5
Douglas-fir. Green, untreated.	June 1916	570	100.0	7.6
Douglas-fir. Seasoned, untreated.	June 1916	571	100.0	7.7
Western larch. Pressure-treated with zinc chloride, 0.8 pound per cubic foot.	June 1932	193	100.0	18.6
Western larch. Green, untreated.	June 1916	551	100.0	7.3
Western larch. Seasoned, untreated.	June 1916	568	100.0	7.4
	Summarization			
Treated ties, both species		390	100.0	18.0
Untreated ties, both species		2,260	100.0	7.5

NORTHERN PACIFIC RAILWAY - THOMPSON FALLS TEST TRACK
Thompson Falls, Montana

In order to carry on this study a test track was established in the main line of the railroad during October 1915, with the Forest Service and the Northern Pacific Railway cooperating. The purpose was to determine the comparative durability of creosoted Douglas-fir, white fir, ponderosa pine, and western larch ties. In addition, it was desired to compare the value of Vignoles rail chairs with standard Northern Pacific plates in reducing mechanical wear and splitting.

This test track originally included 1,675 ties, of which 1,575 were creosoted and 100 were set untreated. It contains 489 feet of tangent between a reverse curve of 1° and 2°, and it is considered to be fairly representative of the results obtainable from the various species under main-line conditions.

About half of the test ties were equipped with Vignoles bolted rail fastenings, which provided for all lateral and vertical adjustments of the rail to the tie without removing bolts. The remainder of the ties were originally equipped with 7" x 9" Northern Pacific tie plates. The track was originally laid with 90-pound rails, but in 1925 the entire test track was relaid with 100-pound rails. When this work was done all of the old Northern Pacific tie plates and Vignoles rail chairs were replaced with the new and latest type of Northern Pacific tie plates. The principal reason for removing all of the rail chairs was that the nuts holding the plates could not be properly tightened because of wornout threads. As long as it was possible to use them, the Vignoles rail chairs rendered good service in preventing excessive plate wear and splitting of the ties.

Table 18 gives data on the durability of the ties placed in the track. All untreated ties, consisting of 50 Rocky Mountain Douglas-fir and 50 western larch ties, were replaced during the period from 1921 to 1926 because of decay. The untreated Douglas-fir ties gave an average life of 7.5 years and the untreated larch, an average life of 6.9 years. Treated ties did considerably better. Although many are still in service, it is estimated that the average life of all treated ties will be close to 24.5 years.

Table 18. - Condition of railway ties in the Northern Pacific test track near Thompson Falls, Montana.

Ties set in October 1915.

Description of ties and preservative treatment	Average age at time inspected, May 1941	Number in test 1/	Total renewals because of wear, breakage, splitting, and decay	Estimated average life
	Years		Percent	Years
Douglas-fir. Pressure-treated with creosote, 6.2 pounds per cubic foot.	25.6	381	74.5	24.0
Douglas-fir. Untreated.	-	50	100.0	7.5
Western larch. Pressure-treated with creosote, 9.0 pounds per cubic foot.	25.6	368	78.5	23.2
Western larch. Untreated.	-	50	100.0	6.9
Lodgepole pine. Pressure treated with creosote, 8.6 pounds per cubic foot.	25.6	190	89.4	21.0
Grand (white) fir. Pressure-treated with creosote, 9.1 pounds per cubic foot.	25.6	196	81.1	22.8
Ponderosa pine. Pressure-treated with creosote, 7.3 pounds per cubic foot.	25.6	368	43.5	29.0
	Summarization			
Treated ties, all species	25.6	1,503	70.7	24.5
Untreated ties, all species	-	100	100.0	7.2

1/ Originally there were 72 other ties in the test track, or a total of 1,575. The 72 ties eliminated were sound and serviceable at the time of removal.

NORTHERN PACIFIC RAILWAY - HEMLOCK TEST TRACK
Missoula, Montana

Early in 1910, the Northern Pacific established a test track near Missoula, Montana, which consisted of 1,072 Inland Empire hemlock ties, 436 western larch, 166 Rocky Mountain Douglas-fir, 102 true fir, 18 Engelmann spruce, and 6 ties of other species. The entire test is located in main-line track at the west end of the Missoula yard.

All ties in the test track were treated by the Lowry pressure process with 6-3/4 pounds per cubic foot of a creosote-coal tar solution, consisting of 80 percent Grade 1 creosote and 20 percent refined coal tar. The ties were originally laid without tie plates, but after about 2 years were equipped with 7" x 9" tie plates. In 1926 the track was relaid with 100-pound rail and 7-3/4" x 10-3/4" Northern Pacific standard plates. The ballast is ordinary pit-run gravel and drainage is not considered good.

Since 1928 the experiment station has helped make annual inspections of these ties. At the 1941 inspection, after 31 years of service, renewals of the western hemlock ties amounted to 55.4 percent and indications are that the average life will be close to 33 years.

In considering the life of these ties, it should be understood that though the test track is on the main line it is not a high-speed track, because of its proximity to the Missoula yard. Nor does the track contain steep grades and sharp curves. Officials of the Northern Pacific believe that the average life figures resulting from this test will be somewhat higher than can be obtained throughout the Rocky Mountain division.

Comparative service records for the experimental ties of each species in this test track are given in table 19.

Table 19. - Condition of railway ties in the Northern Pacific test track at Missoula, Montana.

Ties set in March 1910.

Description of ties and preservative treatment	Average age at time inspected, June 1941	Number in test	Total renewals because of wear, breakage, splitting, and decay	Estimated average life
	Years		Percent	Years
Western hemlock. Pressure-treated with creosote-coal tar solution (80 percent Grade 1 creosote and 20 percent refined coal tar), 6-3/4 pounds per cubic foot.	31.2	1,072	55.4	33.0
Western larch. Same treatment and pres.	31.2	436	39.5	35.0
Douglas-fir. Same treatment and pres.	31.2	166	22.3	38.0
True fir (probably Grand fir). Same treatment and preservative.	31.2	102	49.0	32.0
Engelmann spruce. Same treatment and pres.	31.2	18	77.8	28.0
Idaho white pine. Same treatment and pres.	31.2	2	100.0	30.5 1/
Ponderosa pine. Same treatment and pres.	31.2	3	33.3	36.0
Aspen. Same treatment and preservative.	31.2	1	-	-
	Summarization			
Treated ties, all species	31.2	1,800	48.3	33.8

1/ Actual average life (end of test).

NORTHERN PACIFIC RAILWAY - COTTONWOOD TEST TRACK

Lolo, Montana

Soon after completion of the Northern Pacific tie-treating plant at Paradise, Montana, in April 1908, the railroad established several test tracks. One of these test tracks was constructed in March 1910 near Lolo, Montana, in the Bitterroot branch line. In it are 261 creosoted cottonwood ties cut in western Montana.

The ties were air-seasoned, not bored nor incised, and were treated by the Lowry pressure process. They were impregnated with a solution of 80 percent Grade 1 creosote and 20 percent refined coal tar. Net absorption of the preservative amounted to approximately 8 pounds per cubic foot of wood. The ties were originally laid with dirt ballast and 56-pound rail. In 1918 the ties were equipped with $6\frac{1}{2}$" x 8" plates, and in 1923 the track was relaid with 85-pound rail. Traffic on this branch is not heavy, but during the period when the ties were not protected by tie plates there was some damage from mechanical wear.

For the past 8 years a representative of the experiment station has accompanied officials of the railroad on their annual inspections of these experimental ties. At the 1941 inspection, after 31 years of service, 210 or 80.5 percent of the original ties were still in place. Of this number, 31 were classed as being in good condition and capable of giving at least 5 additional years of service, 104 were classified as being in fair condition with an additional life expectancy of 3 to 4 years, and 75 were classed as badly decayed and needing renewal within about 2 years. With only 51 new ties laid, or 19.5 percent renewals in 31 years, less than 80 percent of the average life of the original ties laid has been realized, and it is expected that the average life to be shown by final figures will be close to 38 years.

The results obtained in this study clearly show the wisdom and economy of treating ties of the so-called minor species, such as cottonwood.

The detailed service records for this installation are contained in table 20.

Table 20. - Condition of railway ties in the Northern Pacific test track (Bitterroot branch line) near Lolo, Montana.

Ties set in March 1910.

Description of ties and preservative treatment	Average age at time inspected, June 1941	Number in test	Condition of ties, June 1941				Estimated average life
			Good 1/	Fair 2/	Poor 3/	Removed because of wear, splitting, breakage, and decay.	
	Years		Percent	Percent	Percent	Percent	Years
Cottonwood. Pressure-treated with creosote-coal tar solution (80 percent Grade 1 creosote and 20 percent refined coal tar), 8 pounds per cubic foot.	31.3	-	11.9	39.8	28.8	19.5	38

1/ "Good" condition means life expectancy of 5 years or more.
2/ "Fair" condition means life expectancy of 3 to 4 years.
3/ "Poor" condition means life expectancy of 1 to 2 years.

ORIGINAL MINE TUNNEL SETS - BUTTE, MONTANA

Anaconda Copper Mining Company

The test timbers covered by this study were installed in the fall of 1911 on the 1,100-foot and the 2,000-foot levels of the Original Mine. At that time the Anaconda Copper Mining Company's wood-preserving plant at Rocker, Montana, had been in operation only about 2 years and the Forest Service cooperated with the company in starting a number of different service tests.

The treated timbers on the 1,100-foot level consisted of 93 pieces (31 caps and 62 posts) of round, pressure-creosoted Douglas-fir, placed in the mine in October 1911. The treated tunnel sets on the 2,000-foot level included 33 caps and 66 posts placed during September 1911. Large timbers ranging from 14 to 18 inches in diameter were used in these sets. The caps were 5½ feet and the posts 8 feet in length. Each set was marked with numbered nails to facilitate future identification.

For the next 16 years these timbers were inspected regularly at intervals of 2 to 3 years. However, during the latter part of that period no ore was being mined on either the 1,100- or the 2,000-foot level, and in later years both of the tunnels became blocked by cave-ins which prevented the collection of additional service records. Although discontinuance of the test could not be avoided, sufficient evidence was collected to demonstrate the effectiveness of the treatment applied. At the last inspection on September 27, 1927, after 16 years of service, approximately 47 percent of the total of 184 pieces still in the test were in sound condition, 36 percent were slightly affected by decay but would give several more years of service, 13 percent were badly decayed, and 4 percent had been removed on account of decay.

If it had been essential to maintain permanent openings on each of the levels where this test was conducted, it is safe to say that the treated test timbers set in 1911 would have given an average life of 20 years or more. Untreated timbers used under similar conditions would have required replacement within 6 or 7 years, perhaps sooner.

Summarized records covering the final inspection of these experimental timbers are given in table 21.

Table 21. - Condition of Anaconda Copper Mining Company tunnel sets in the Original Mine, Butte, Montana.

Posts and caps set in September and October, 1911.

Description of timbers and preservative treatment	Location in mine	Average age at time inspected	Number in test	Condition of timbers, September 1927				Estimated average life
				Good	Partly decayed	Badly decayed	Removed because of decay	
		Years		Percent	Percent	Percent	Percent	Years
Douglas-fir posts. Round, average 15-inch top diameter, 8 feet long, seasoned. Pressure-treated with creosote. Average absorption, 2.66 pounds per cubic foot.	1100-ft. level	16.0	60	43.3	26.7	18.3	11.7	Over 20
Douglas-fir caps. Round, average 15-inch top diameter, 5½ feet long long, seasoned. Pressure-treated with creosote. Average absorption, 2.66 pounds per cubic foot.	"	16.0	30	76.7	23.3	-	-	Over 20
Douglas-fir posts. Round, average 15-inch top diameter, 8 feet long, seasoned. Pressure-treated with creosote. Average absorption, 2.66 pounds per cubic foot.	2000-ft. level	16.0	62	37.1	46.8	16.1	-	Over 20
Douglas-fir caps. Round, average 15-inch top diameter, 5½ feet long, seasoned. Pressure-treated with creosote. Average absorption, 2.66 pounds per cubic foot.	"	16.0	32	43.75	43.75	12.5	-	Over 20
Total		16.0	184 1/	46.7	35.9	13.6	3.8	

1/ Originally there were 192 pieces in the test, of which 8 were eliminated because of reconstruction.

Selected List of Publications

Information regarding the wood preservatives and treating processes mentioned on the preceding pages may be obtained from the following publications:

Bulletins

Manual on preservative treatment of wood by pressure, by J. D. MacLean. U. S. Department of Agriculture, Miscellaneous Publication No. 224. August 1935. For sale by the Superintendent of Documents, Washington, D. C. Price 15 cents.

Preservative treatment of farm timbers, by G. M. Hunt. U. S. Department of Agriculture, Farmers' Bulletin No. 744. Revised 1928. For sale by the Superintendent of Documents, Washington, D. C. Price 5 cents.

Mimeographs

Wood preservatives. Revised 1941. A copy may be obtained free on request to the Forest Products Laboratory, Madison, Wisconsin.

Methods of applying wood preservatives. Revised 1940. A copy may be obtained free on request to the Forest Products Laboratory, Madison, Wisconsin.

Preservation of timber by the steeping process, by R. M. Wirka. Revised 1939. A copy may be obtained free on request to the Forest Products Laboratory, Madison, Wisconsin.

Instructions for preservative treatment of telephone poles, stubs, and fence posts, by C. N. Whitney. Second edition, February 1941. A copy may be obtained free on request to the Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Montana.